Predictability Studies Using the Intraseasonal Variability Hindcast Experiment (ISVHE)

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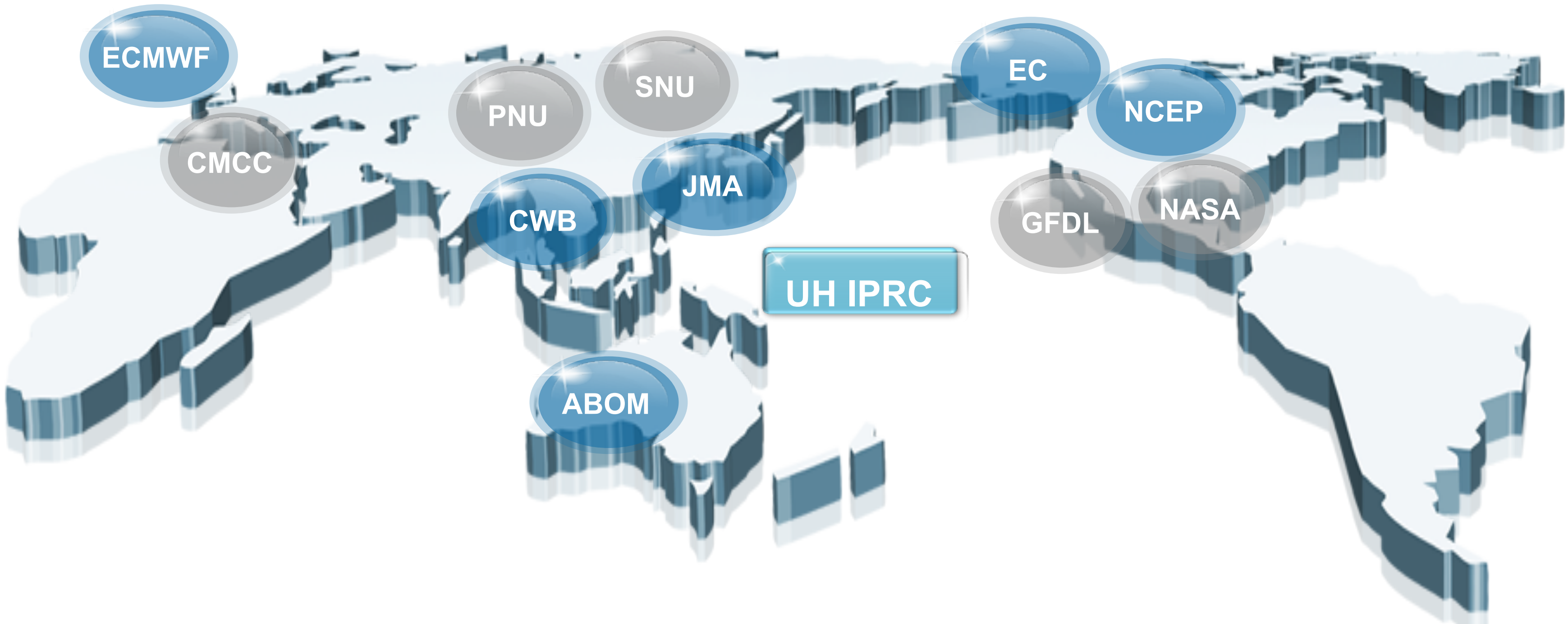
and participating modeling groups

ISVHE

Intraseasonal Variability (ISV) Hindcast Experiment

The **ISVHE** was the **FIRST** coordinated multi-institutional ISV hindcast experiment. Called for in 2007 MJO Workshop. Invitations/Experimental design initiated 2009. Simulations completed around 2011. Analysis phase 2012-2014. Initial Papers completed 2014-15.



Supporters

YOTC
MJO WG/TF

CTB

Additional support provided to this work by

Presentation Based on

- *Neena, J.M., J-Yi Lee, D. Waliser, B. Wang and X. Jiang: 2014a, Predictability of the* ***Madden Julian Oscillation*** *in the Intraseasonal Variability Hindcast Experiment (ISVHE), J Climate, 27,* 4531-4543.

- *Neena, J.M., X. Jiang, D. Waliser, J-Yi Lee, and B. Wang, 2014b,* Prediction skill and predictability of **Eastern Pacific Intraseasonal Variability**, *J. Climate, 27, 8869–8883.*

- *Lee, S.-S., B. Wang, D. Waliser, Neena, J.M., and J-Yi Lee, 2015: Predictability And Prediction Skill Of The* ***Boreal Summer Intraseasonal Oscillation*** *In The Intraseasonal Variability Hindcast Experiment, Climate Dynamics,* DOI 10.1007/s00382-014-2461-5.

- *Lee, J.-Y., et al. manuscript in preparation –* ***MME results***

Description of Models and Experiments

One-Tier Coupled Model Systems

ISVHE

	Model	ISO Hindcast		
		Period	Ens No	Initial Condition
ABOM1	POAMA 1.5 & 2.4 (ACOM2+BAM3)	1980-2006	10	The first day of every month
ABOM2	POAMA 2.4 (ACOM2+BAM3)	1989-2009	11	The 1st and 11th day of every month
ECMWF	ECMWF (IFS+HOPE)	1989-2008	5	The first day of every month
CMCC	CMCC (ECHAM5+OPA8.2)	1989-2007	5	The 1st 11th and 21st day of every month
JMA	JMA CGCM	1989-2008	5	Every 15th day
NCEP/CPC	CFS v1 (GFS+MOM3)	1981-2008	5	The 2nd 12th and 22nd day of every month
NCEP/CPC	CFS v2	1999-2010	5	The 1st 11th and 21st day of every month
SNU	SNU CM (SNUAGCM+MOM3)	1990-2008	4	The 1st 11th and 21st day of every month

Analysis & Presentation Objectives

Primary Objective

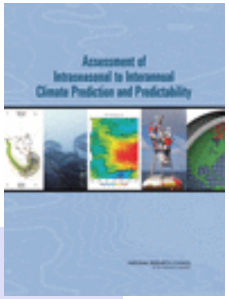
- Present Estimates of ISV Predictability
  - ✓ *Employ better & more models*
  - ✓ *Use community standard indices (e.g.WH'04)*
  - ✓ *MJO, BSISO, (first estimate of) E Pacific ISV*

Revisit e.g.
Waliser et al. (2003, 2004),
Fu et al. (2007),
Pegion and Kirtman (2008)

Secondary Objectives

- Quantify gap between predictability and prediction skill
- Examine "ensemble fidelity" on enhancement of prediction skill

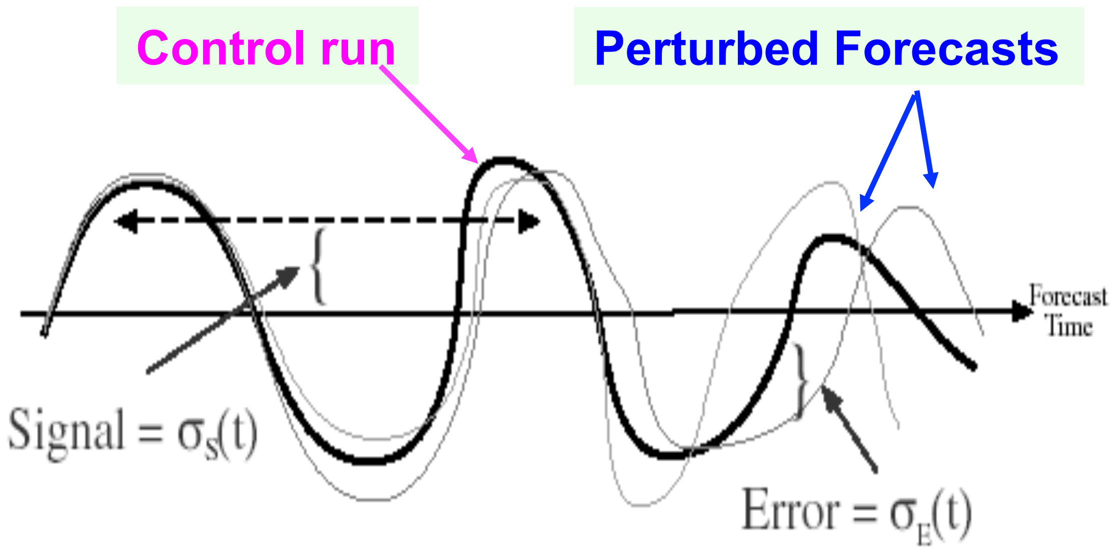
U.S. NAS ISI
Study 2010



Definitions:
Predictability – characteristic of a natural phenomena – often estimated with models
Prediction skill – characteristic of a model and its forecast fidelity against observations

Ensemble - only refers to single model's ensemble of forecasts – not MME

Signal To Error Ratio Estimate Of MJO/ISV Predictability



Initial Condition Differences Based On Forecasts 1 Day Apart

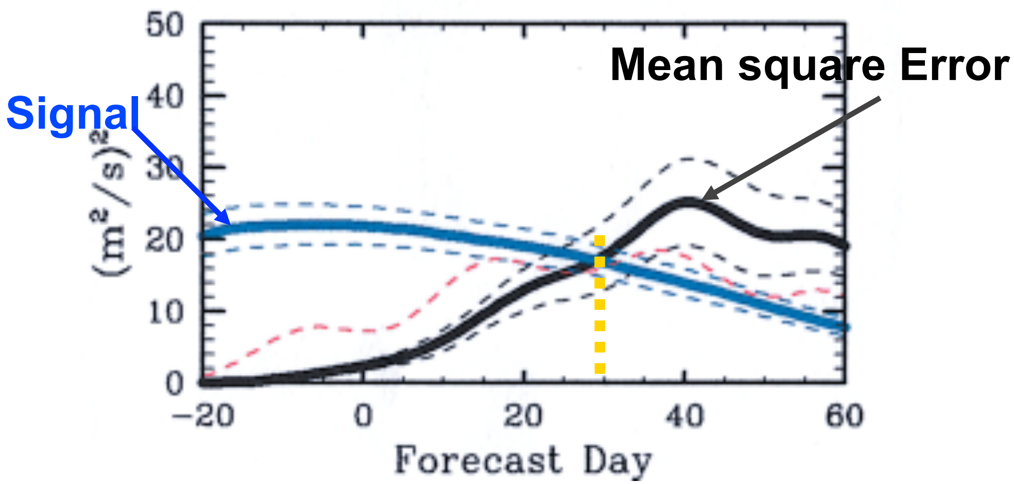
Signal (L=25 days)

$$\sigma^2_{S_{ij}} = \frac{1}{2L+1}\sum_{\tau=-L}^{L}(X^0_{i,j+\tau})^2$$

Error

$$\sigma^2_{E_{ijk}} = (X^k_{ij} - X^0_{ij})^2$$

$X^0_{ij} =$ { Predictability = Model Control; Prediction Skill = Observations }



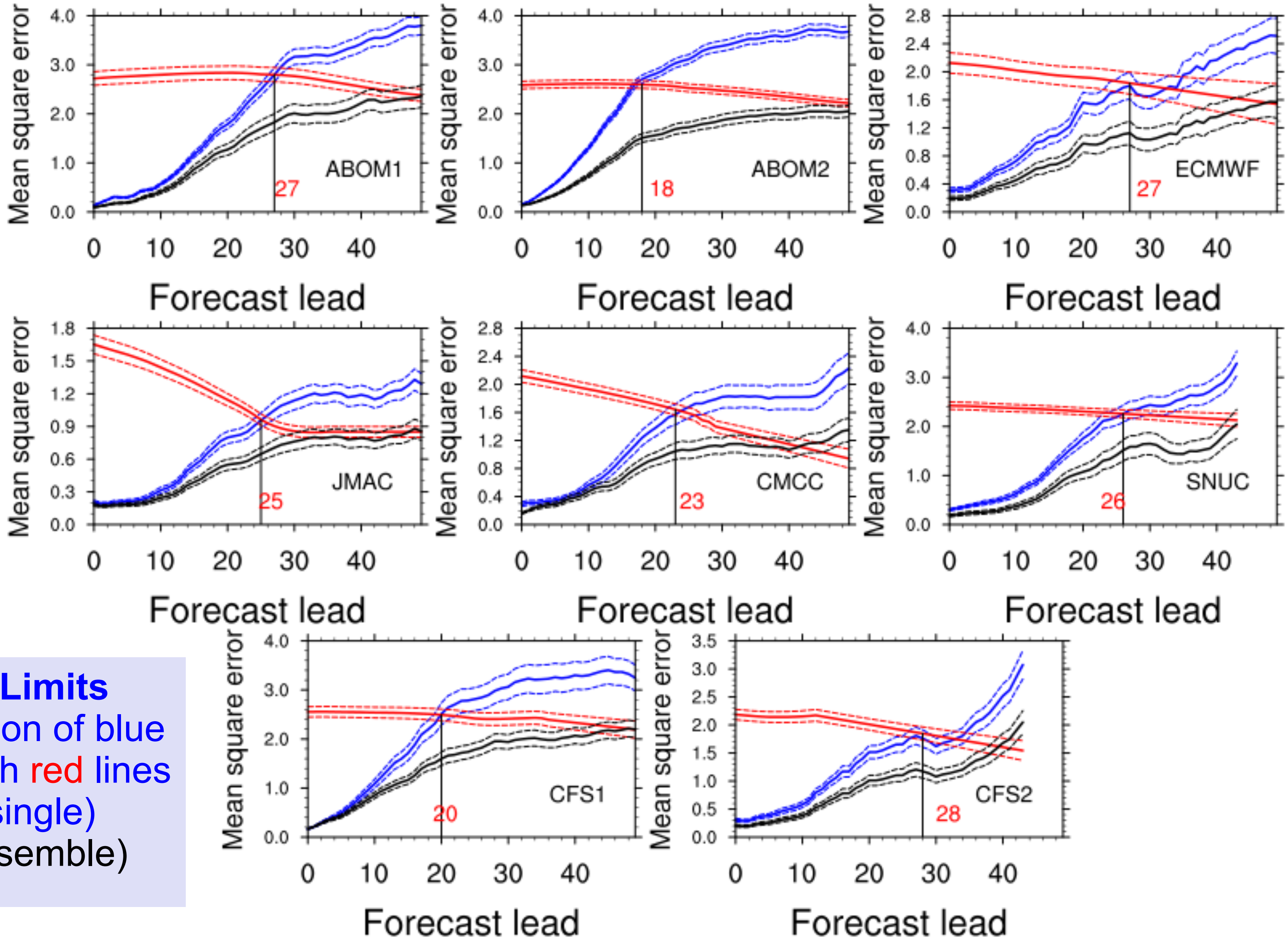
As in
Waliser et al. (2003, 2004);
Liess et al. (2005); Fu et al. (2007)
Except using a modern indices (e.g. RMM1 & RMM2 for MJO)

Bivariate estimates of Signal and Error

$$E^2_{ij} = (RMM1^{k1}_{ij} - RMM1^{k2}_{ij})^2 + (RMM2^{k1}_{ij} - RMM2^{k2}_{ij})^2$$

$$S^2_{ijk} = 1/51 \times \sum_{t=-L}^{L} (RMM1_{ik\,j+t})^2 + (RMM2_{ik\,j+t})^2$$

MJO Predictability in the ISVHE

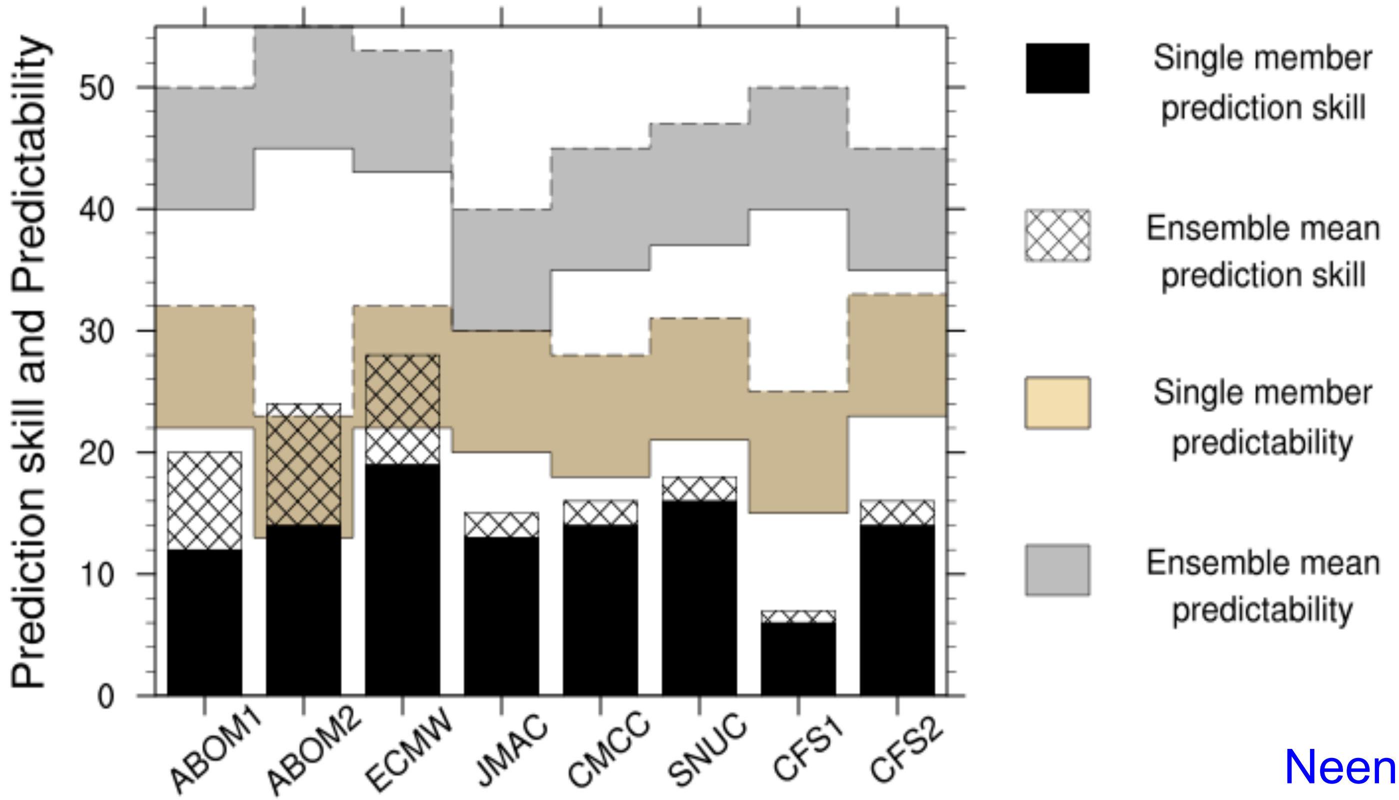


Predictability Limits
given by intersection of blue OR black lines with red lines
20-30 days (single)
40-50 days (ensemble)

Signal- Red curve
Error – Blue Curves – Single Member Estimates
Error – Black Curves – Ensemble Estimates

Neena et al. 2014a

MJO Prediction vs Predictability----Where Do We Stand?



Skill ~ 2 weeks

Skill ~ 2-3 weeks

Pred ~ 3-4 weeks

Pred ~ 5-7 weeks

Neena et al. 2014a

* Predictability estimates are shown as +/- 5 day range

- Significant skill remaining to be exploited by improving MJO forecast systems *(e.g. ICs, data assimilation, model fidelity)*

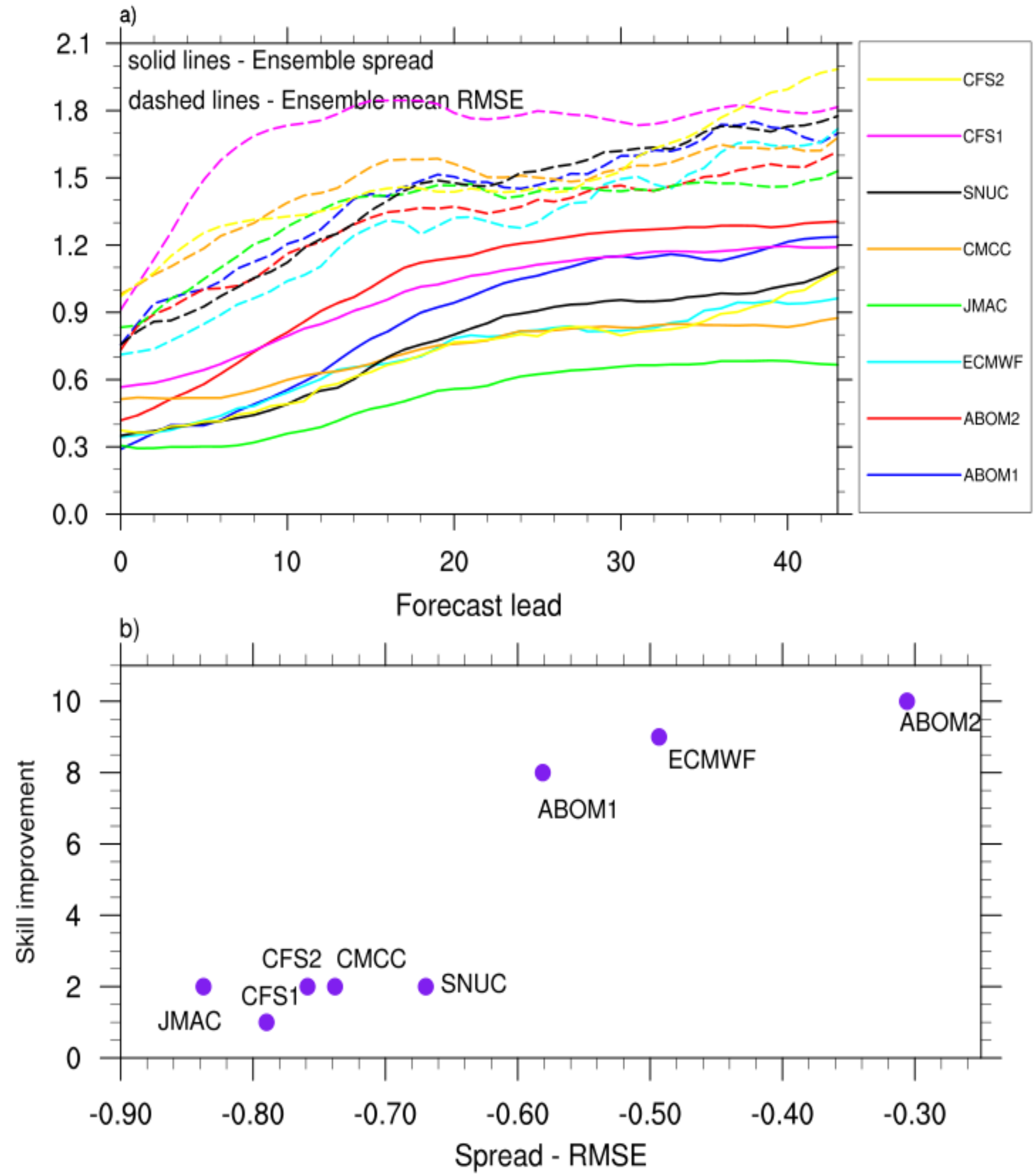
- High-quality ensemble prediction systems crucial for MJO forecasting.

Ensemble Fidelity And Improvement In MJO Prediction Skill

In a statistically consistent ensemble, the RMS forecast error of the ensemble mean (dashed) should match the standard deviation of the ensemble members (ensemble spread) (solid).

Ensemble Fidelity - average difference between the solid and dashed curves over the first 25 days hindcast

Prediction systems with greater MJO Ensemble Fidelity show more improvement in the ensemble mean prediction skill over the individual ensemble member hindcast skill!



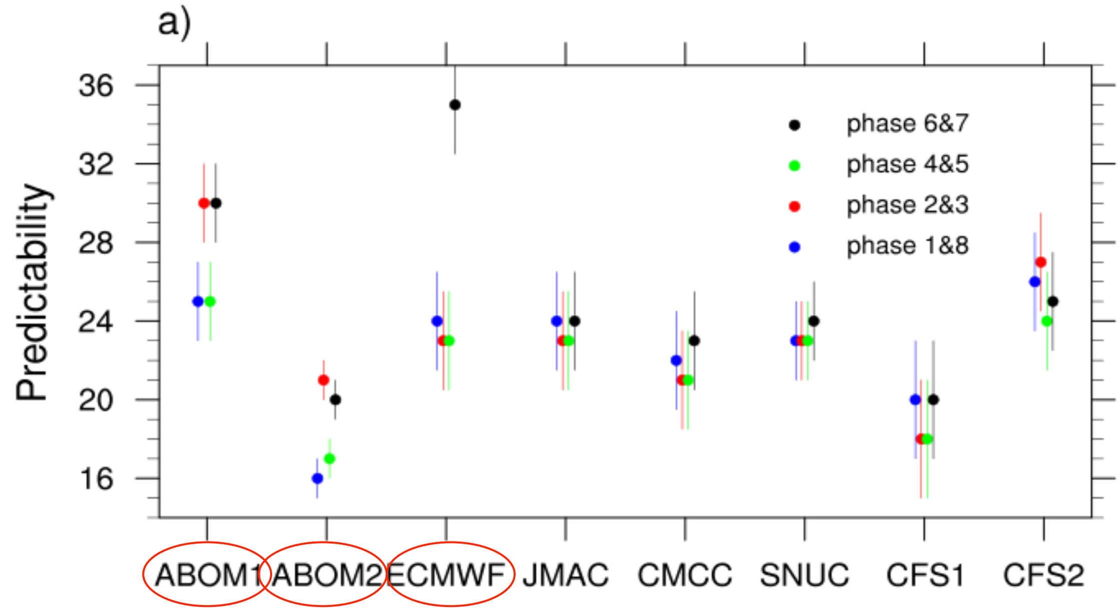
Neena et al. 2014a

Predictability Dependence On MJO Phase And Primary/Secondary

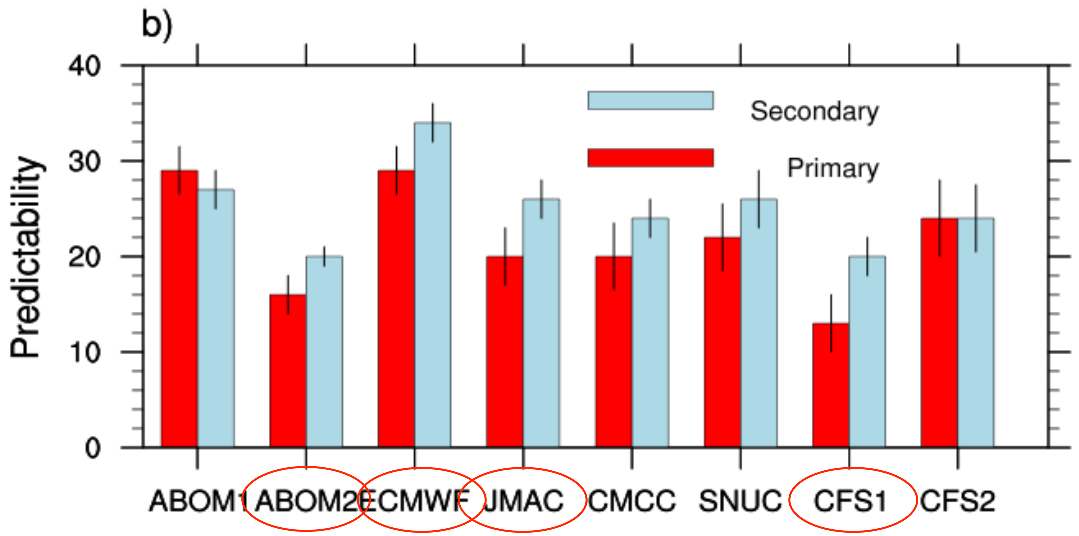
a) Hindcasts are grouped according to the RMM phase during hindcast initiation
b) Hindcasts are grouped into those associated with primary/secondary MJO events using the RMM index based classification of Straub (2012)

Only 3 (of 8) models exhibit predictability phase dependence (ABOM1, ABOM2,ECMWF)

-> E. Hemisphere convection more predictable (e.g. Phases 8,1,2,3)



Hindcasts initiated from secondary MJO events have greater predictability (~5 days) than those from primary events in 4 of 8 (~6 of 8) models.
(ABOM2, ECMWF, JMAC,CFS1)



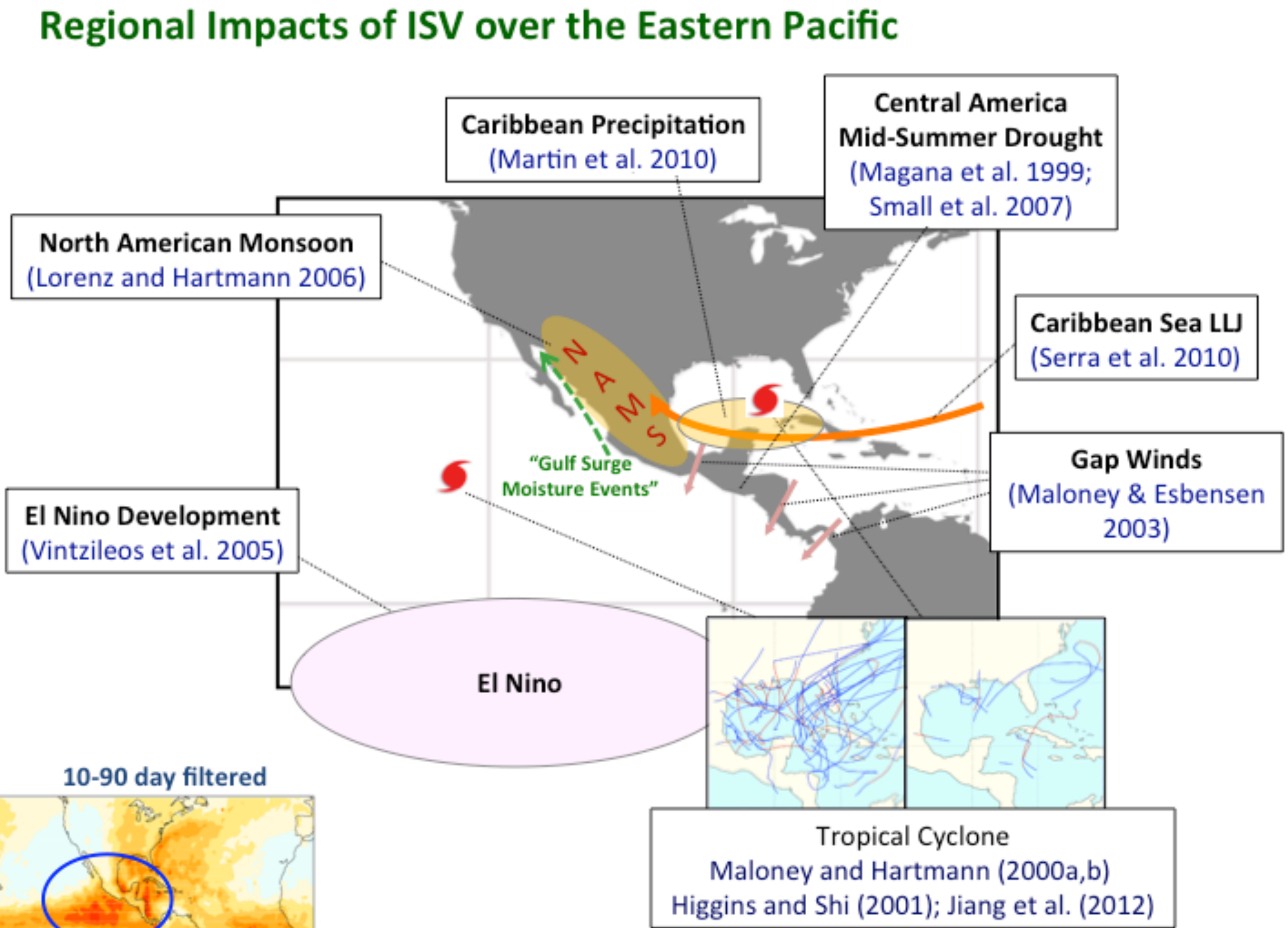
Red circles imply statistically significant

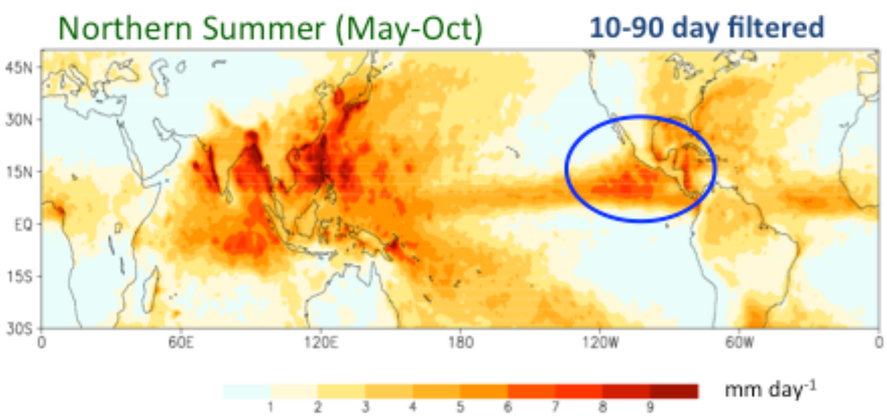
Eastern Pacific ISV

Models illustrate some fidelity at representing E. PacIfic ISV (e.g. Jiang et al. 2012, 2013)

Few, if any, multi-model studies on predictability and prediction skill.

Use ISVHE estimate predictability and contemporary prediction skill.

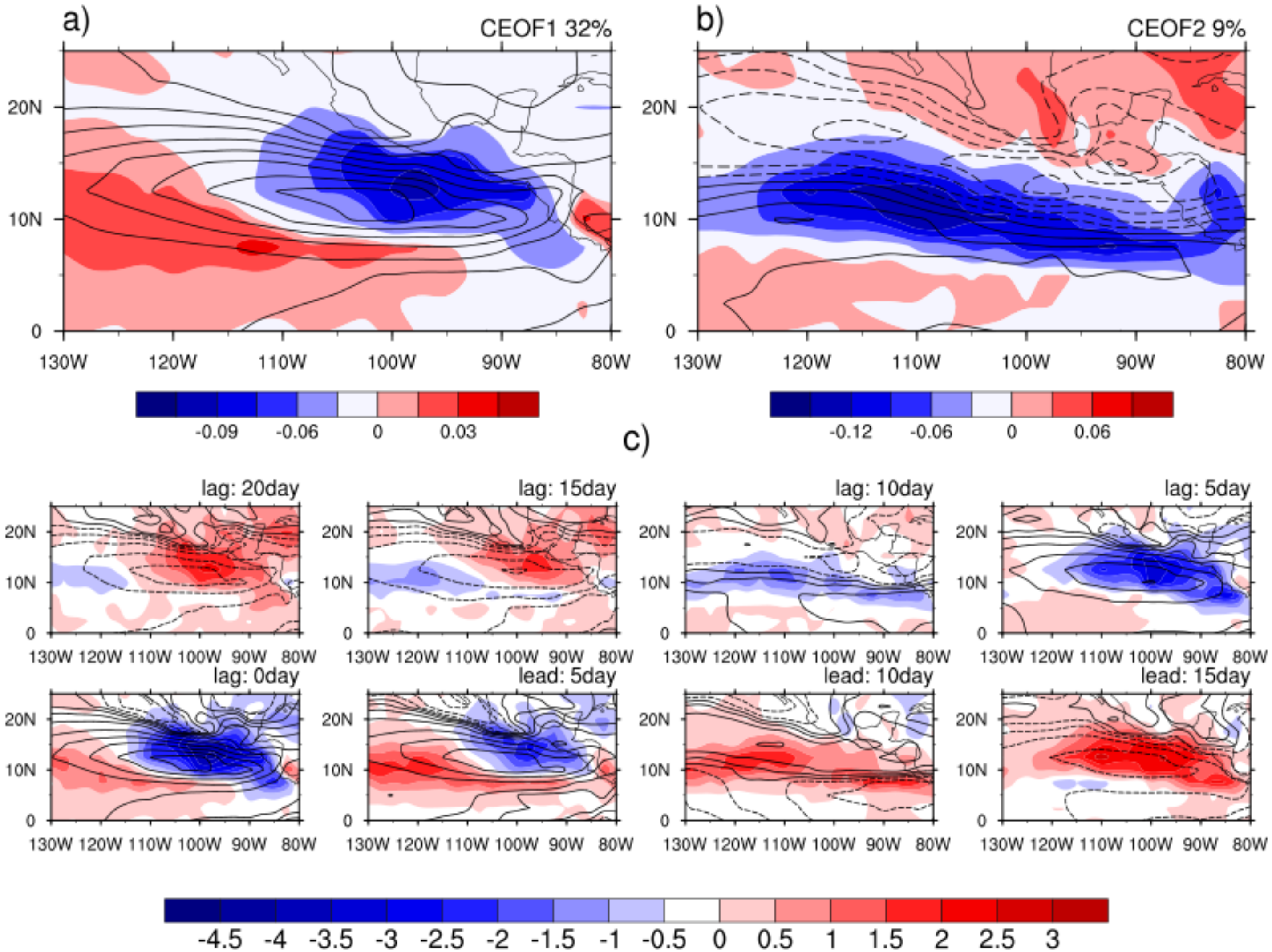




Figures courtesy, X. Jiang (UCLA/JPL)

Eastern Pacific ISV – Dominant Modes

CEOF Mode 1 – 32% **CEOF Mode 2 – 9%**

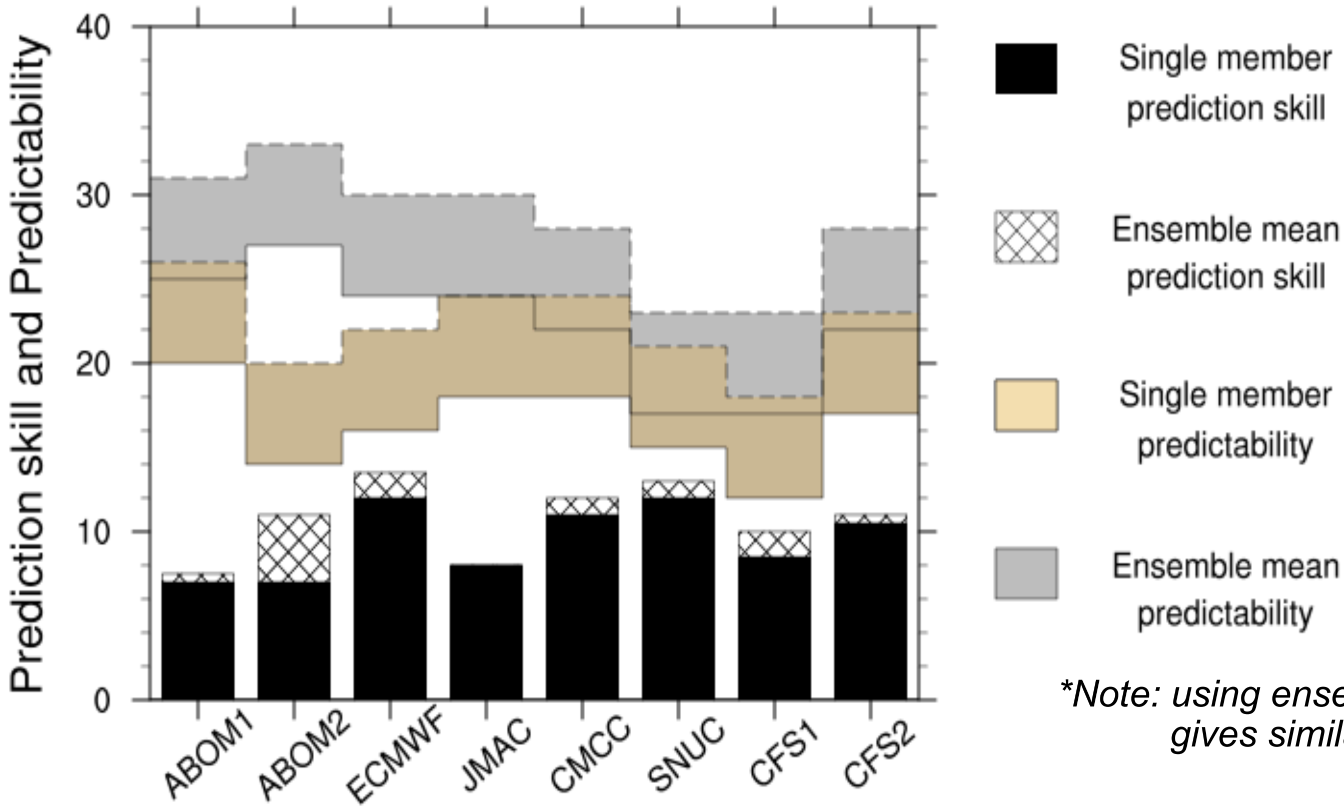


EPAC ISV mode is isolated using combined EOF analysis of 20-100 day filtered TRMM precipitation and U850 over 230-280E, 0- 25N.

Bottom Plots: Regressed 20-100 day filtered precipitation (shaded) and u850 (contour) anomalies wrt PC1 and PC2.

Neena et al. 2014b

EPAC ISV Mode 1 Predictability & Prediction Skill



Skill ~ 10 days

Skill ~ 12 days

Pred ~ 15-23 days

Pred ~ 20-30 days

**Note: using ensemble mean for Signal and Error gives similar Predictability estimates*

Neena et al. 2014b

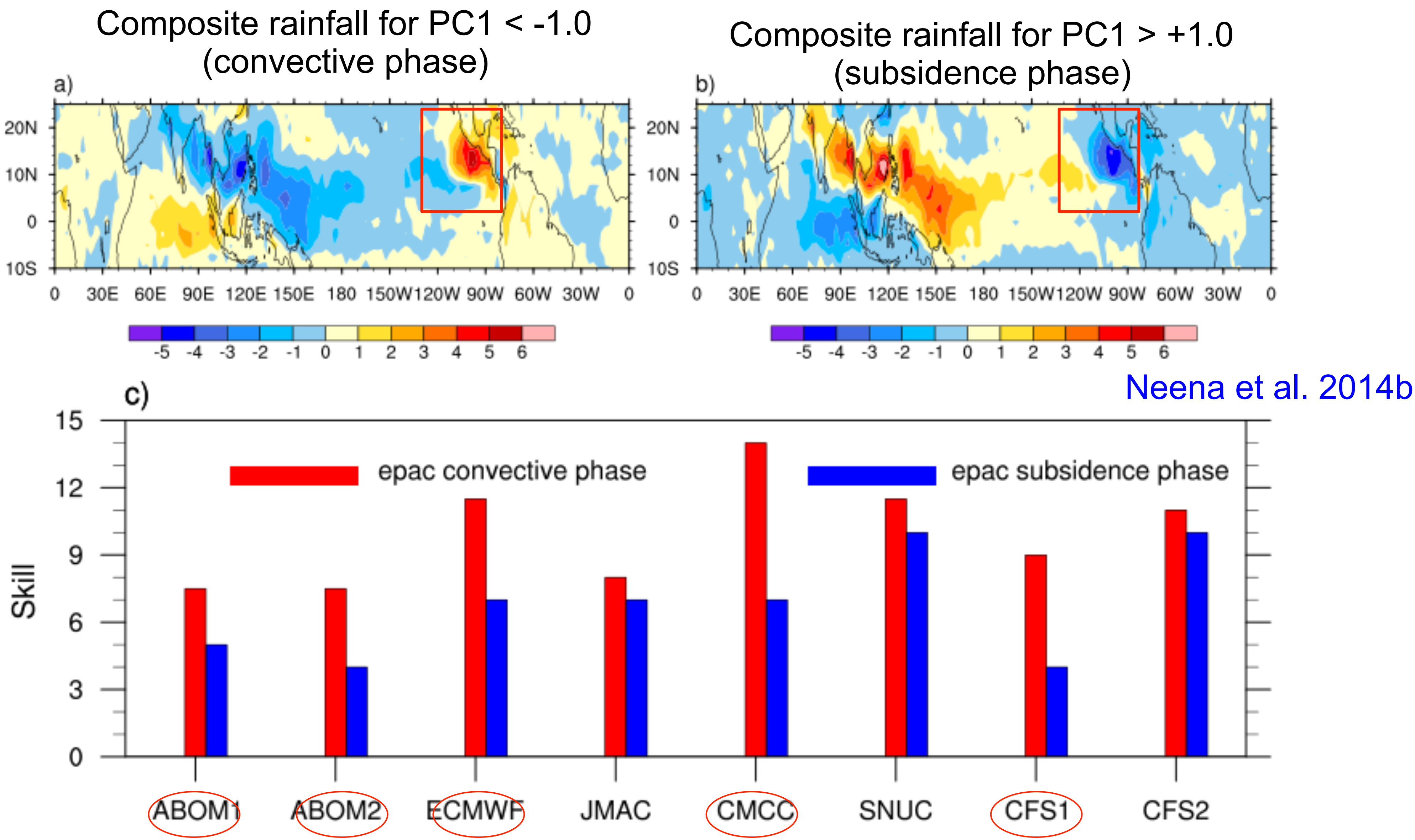
Typical single member prediction skill for E.Pac ISV is 8-15 days.

Ensemble prediction only slightly improves the skill.

Predictability estimates for E.Pac ISV is about 20-30 days.

* Predictability estimates are shown as +/- 3 day range

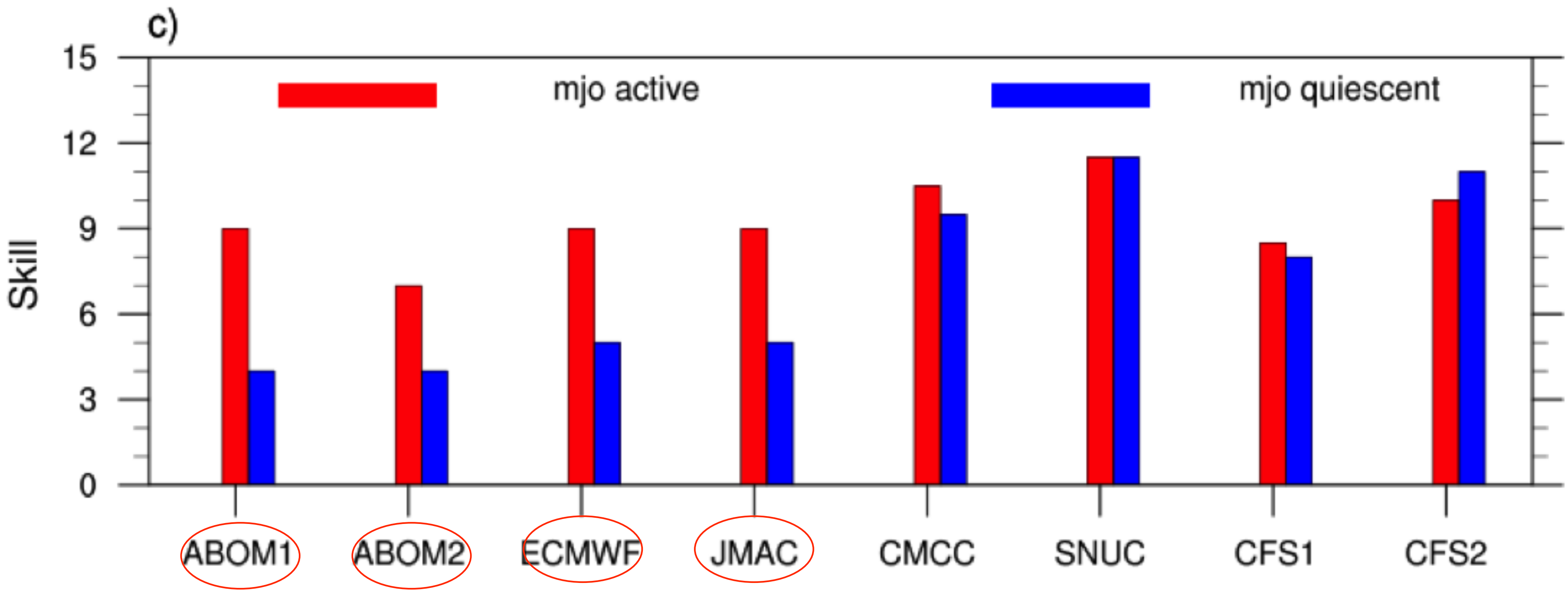
Prediction Skill : EPAC ISV Convective Vs Subsidence Phases



Higher prediction skill (3-5 days) is associated with hindcasts initiated from the EPAC ISV convective phase as compared to those in the subsidence phase.

EPAC ISV Prediction Skill vs MJO Activity

Hindcasts divided between Active MJO (>= 1.0) and Quiescent MJO (< 1.0)



Four models exhibit distinctly higher prediction skill (3-5 days) for EPAC ISV in under active MJO conditions

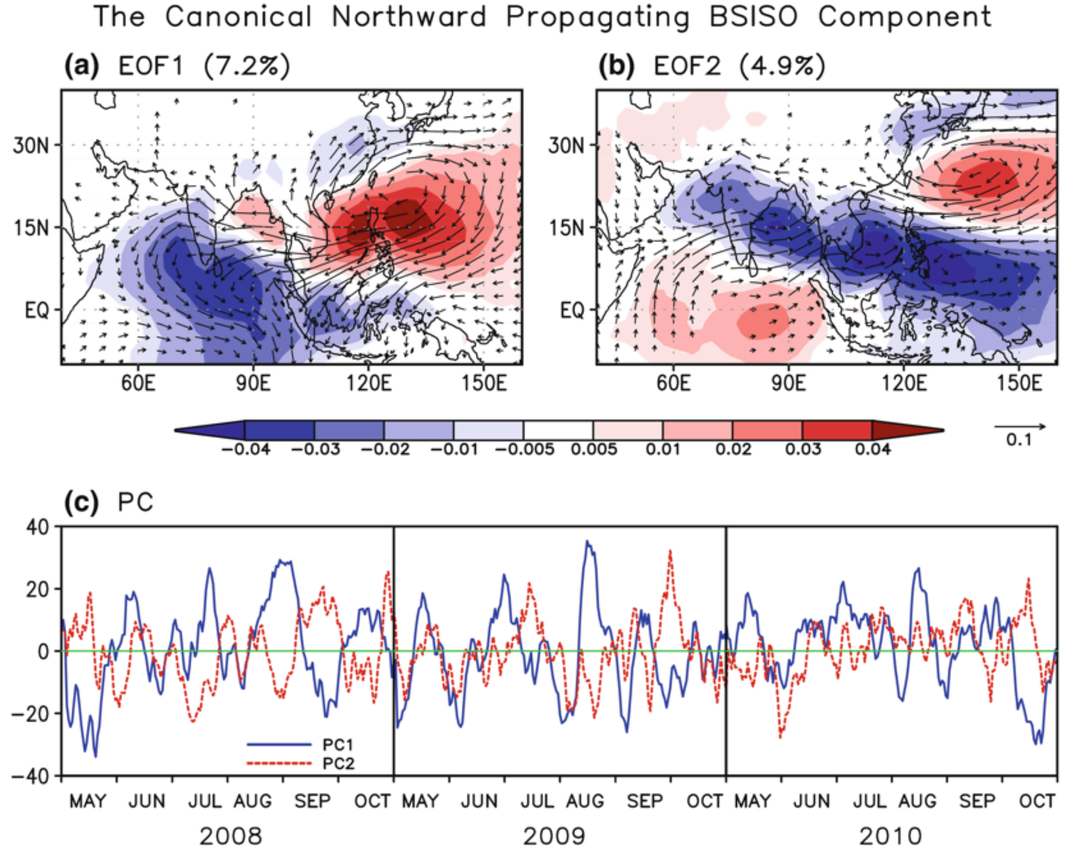
Neena et al. 2014b

Boreal Summer Intraseasonal Oscillation (BSISO)

- ❑ **Observed BSISO index:**

Combined EOF of daily anomalies of outgoing longwave radiation (OLR) and 850-hPa zonal wind (U850) over [10°S-40°N, 40°E-160°E]

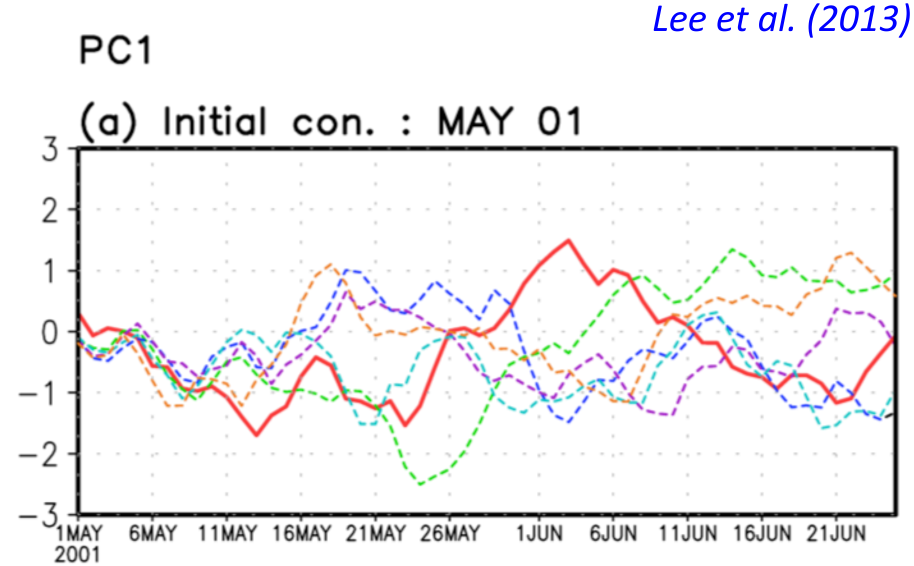
→ **BSISO1 (EOF1 and EOF2)** and BSISO2(EOF3 and EOF4)



Lee et al. (2013)

- ❑ **Hindcast BSISO index**

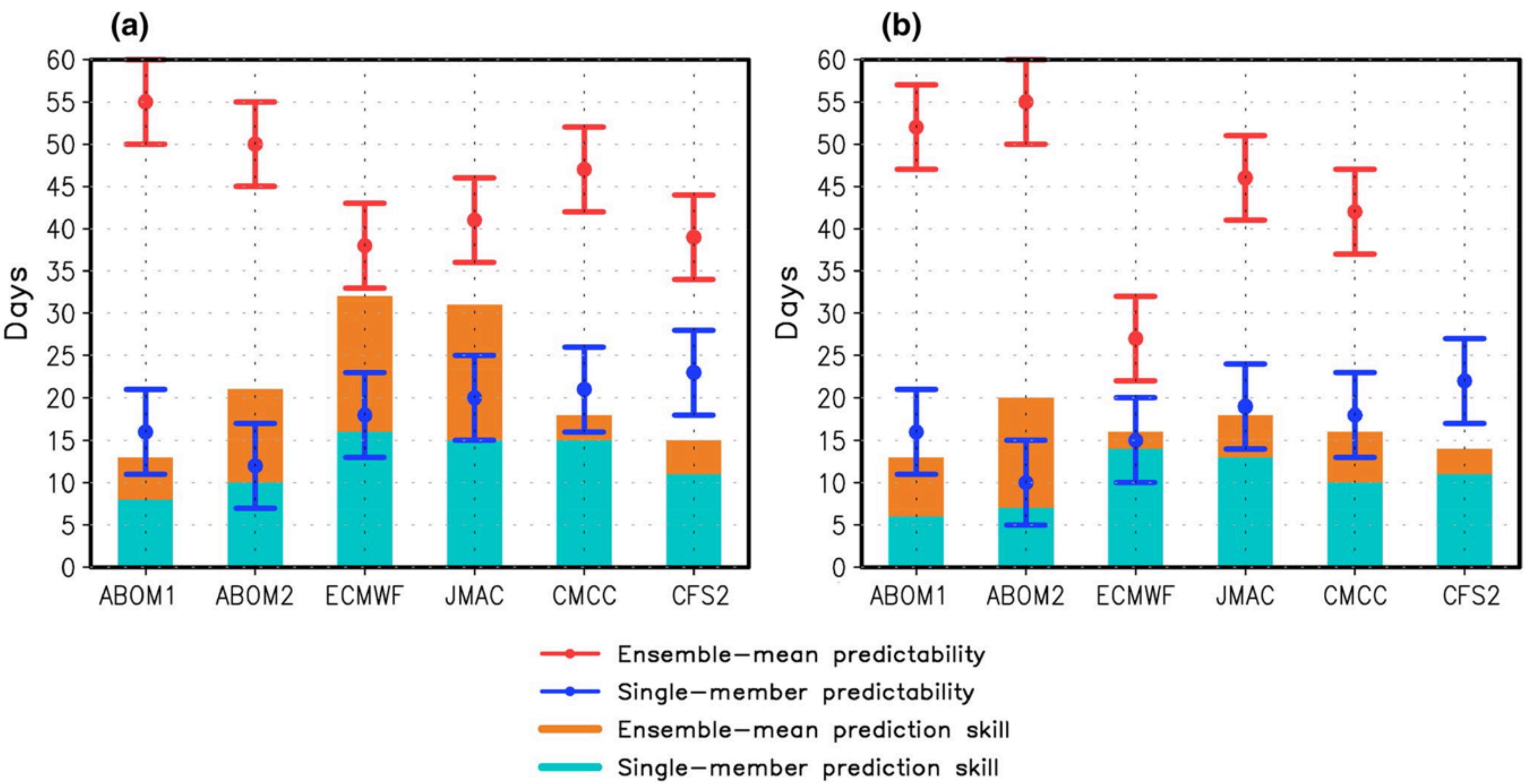
Indices obtained by projecting combined two anomaly fields (OLR & U850) of hindcast onto the observed BSISO EOF modes.



Solid: observation
Dashed: hindcast

S.-S. Lee et al 2015

Predictability and Prediction of BSISO



	Strong BSISO IC	Weak BSISO IC
Prediction skill	~ 3 weeks	~2 weeks
Predictability	~ 6weeks	~6 weeks

Prediction skill depends on the initial amplitude, longer for strong BSISO.

Predictability estimates do not depend on the initial amplitude.

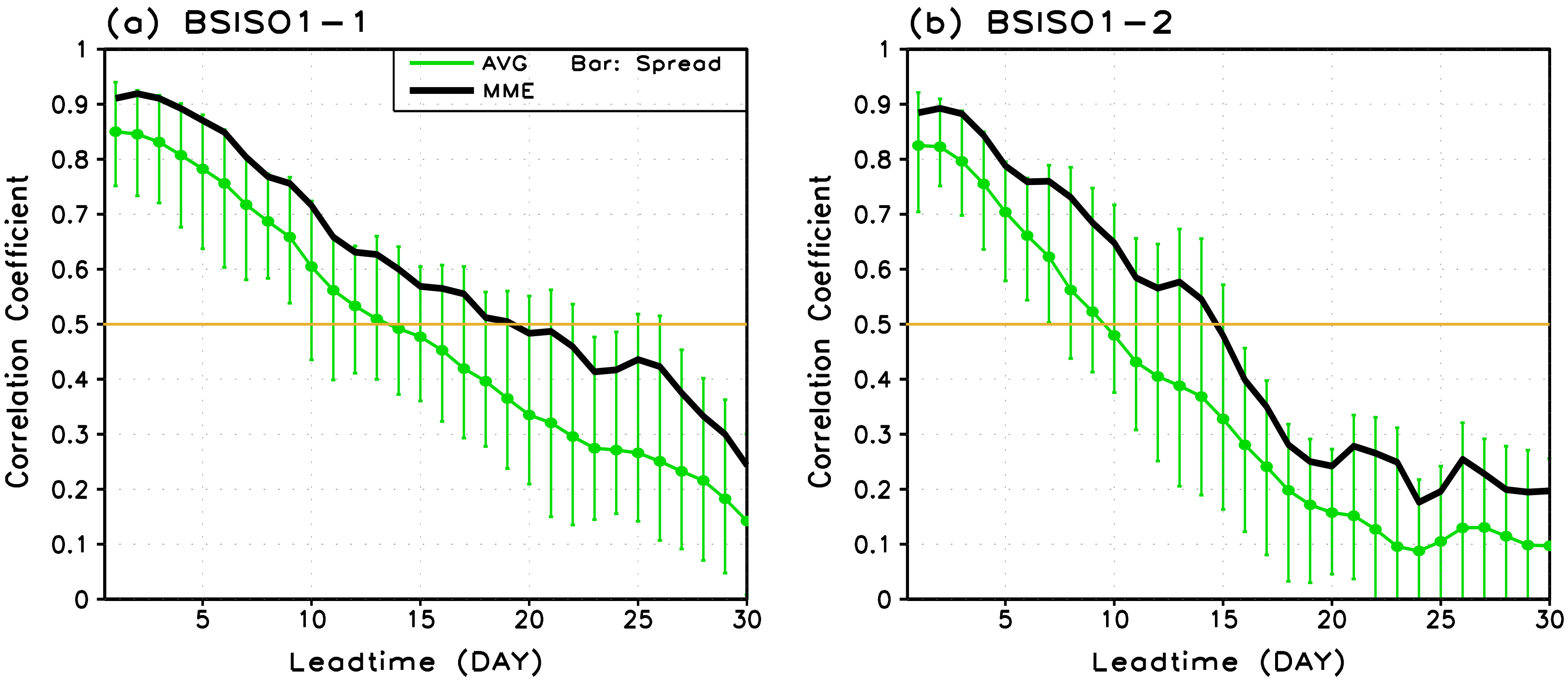
Values illustrated are based on ensemble mean approach

S.-S. Lee et al 2015

The MME and Individual Models' Skill for BSISO

BSISO1 (= EOF1+EOF2)

Anomaly Correlation Coefficients (1989-2008, MJJASO)



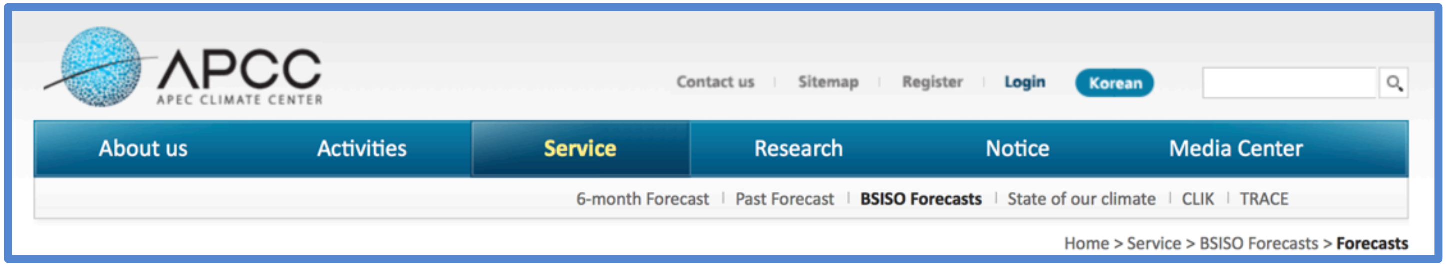
Common Period: 1989-2008
Initial Condition: 1st day of each month from Oct-Mar
MME: Simple composite with all models

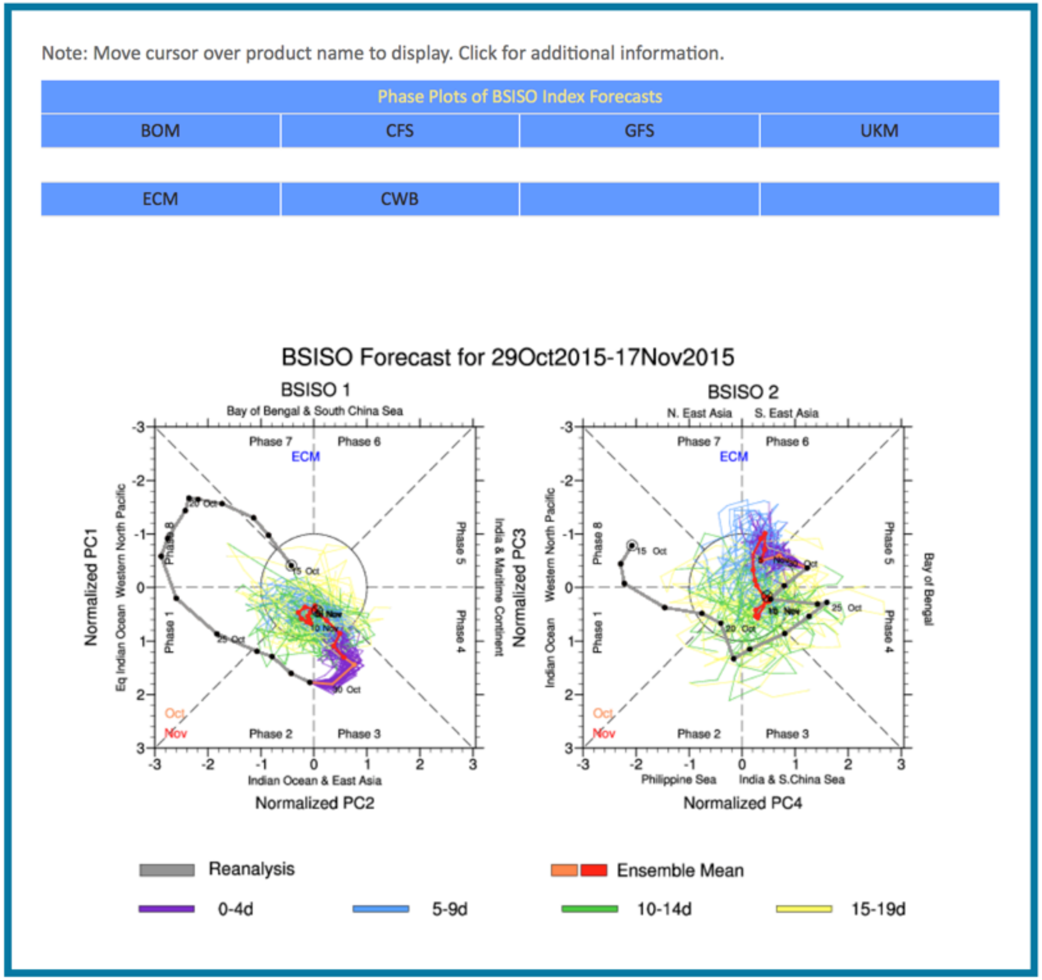
Courtesy, J.-Y. Lee
Pusan National Univ

Using the MME, forecast skill for BSISO1 reaches 0.5 at 15 to 20-day forecast lead

BSISO Real-time Monitoring And Forecast

In cooperation with the WGNE MJO TF, APCC has hosted real-time monitoring and forecast of BSISO indices since 2013 summer.





Courtesy, J.-Y. Lee; Pusan National Univ

http://www.apcc21.org

Summary

The predictability & prediction skill of boreal winter MJO and summer EPAC ISV and BSISO is investigated in the ISVHE hindcasts of eight coupled models.

- MJO predictability is about 40-50 days across the various ISVHE models.
- MJO predictability slightly better in some models when initial state has convection in Eastern vs Western Hemisphere and for secondary versus primary MJO events.
- Still a significant gap (~ 2-3 weeks or more) between MJO prediction skill and predictability estimates.
- In addition to improving the dynamic models, devising ensemble generation approaches tailored for the MJO would have a considerable impact on MJO ensemble prediction.

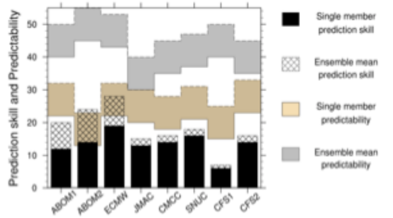
- EPAC ISV predictability is about 20-30 days across the various ISVHE models.
- EPAC ISV prediction skill slightly better in some most/some models when initial state has convection vs subsidence in EPAC and for active vs quiescent MJO conditions.
- Ensemble average EPAC ISV forecasts does not show much improvement over single member in the EPAC for the model/forecast systems analyzed.

- BSISO predictability is about 40-50 days across the various ISVHE models.
- MME improves prediction skill at 0.5 correlation by 5 days lead time.

Future Work – e.g. with S2S Project Database

Revisit ISV Predictability and Prediction Skill Estimates

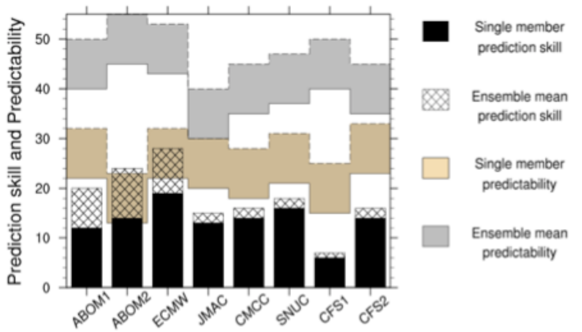
- ✓ *Models are 5+ years more advanced*
- ✓ *All operational versions*
- ✓ *Ensemble sizes/characteristics better*



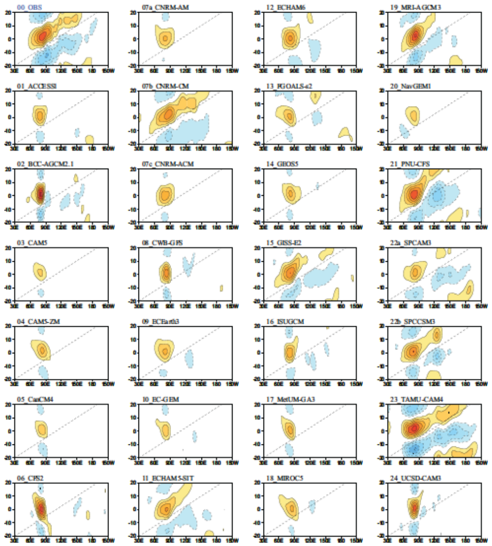
- Focus on Conditional Sampling
  - ✧ *Examine extreme cases and/or cases that exhibit particularly good/poor predictability and/or skill – why?*
  - ✧ *Condition on other modes of variability*
  - ✧ *Initiation – 1-3 weeks prior*

- Examine how Predictability and Prediction Skill extends beyond "indices" (e.g. WH index) to specific quantities (e.g. T, Prec) and regions most strongly influenced by these ISV modes

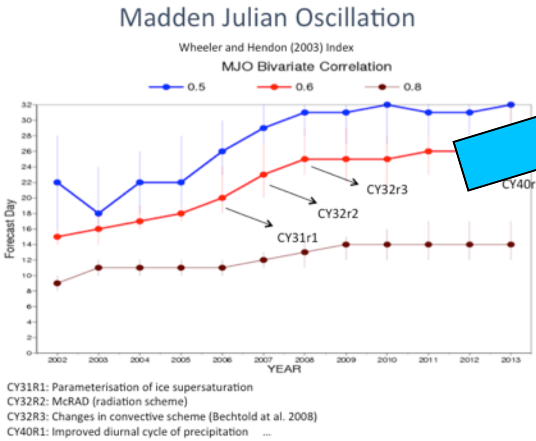
A Prediction of Predictions



Neena et al. (2014)



Jiang et al. (2015)



Vitart (2014, 2018, 2022)

Cheers